Transpositions

Transpositions can be installed on transmission lines to balance the capacitances to earth of their conductors. This equalizes the impedance of the three phases and minimizes inductive interferences with other lines. As a common practice, PG&E no longer installs transpositions on their transmission lines except for long lines. But, if a line longer than indicated below is contemplated, permission must be received from the communication companies in the area to omit transpositions (G.O. 52, Rule IIIc).

1. Horizontal single-circuit lines over 6 miles in length.
2. Triangular single-circuit lines over 12 miles in length.
3. Double-circuit lines over 9 miles in length.
4. If the line is in close proximity to multiple communication lines exceeding 1 mile in total length in each 10 consecutive miles of the transmission line.
5. If the line is in close proximity to one communication line exceeding 1 mile in total length in each 30 consecutive miles.

Close proximity is defined as separated from an existing communication line or highway where a future communication line may be constructed by less than 850 feet for 60 kV, and 1,000 feet for 115 kV and above. Crossings at angles over 30° are exempted from this requirement.

For 500 kV circuits, lines will be transposed to complete a barrel between terminals.

Transmission Line Switches

Transmission line switches shall be installed when required by transmission planning and/or system operations personnel. Before selecting the appropriate transmission line switch, a Line Switch Information Data Sheet must be completed and approved by system operations personnel.

Resistive glaze (RG) post insulators, as described in Document 067906, will be used in **all** insulation districts.

Table 15 Transmission Line Switch Standards and Guidelines

Title	Document
Line-Tension Type Air Switch Installation, 44-70 kV Pole Lines (For Reference Only)	048876
115 kV Pole-Mounted Switches	TD-1006S
Specifications for 115 kV Air Switch Poles	
115 kV Air Switch Pole, Miscellaneous Components	
Transmission Field Switch Operation Limitations	–
Installation of Switch Grounds on Steel Structures, 60-230 kV Transmission Lines	065383
Installation of Grounds on Wood Pole Transmission and Distribution Lines	021904
115 kV and 230 kV Line Switches Mounted on Transmission Structures	463236
Post-Type Apparatus Insulators	067906
Application of Aluminum Conductors and Connections for Substation Use	037788

Grounding Requirements

Electrical equipment and structures are grounded to eliminate potentially hazardous stray currents and/or voltages. For grounding requirements on wood poles, see Document 021904. For grounding steel structures, see Document 012566. For grounding fences, see Document 020607.

Grounding requirements for transmission line towers and poles inside the substation fence must be carefully designed. Treat these structures like any metallic structure inside the substation and conduct a specific analysis to determine the exact grounding requirements. If the structure is more than 8 feet outside the substation fence, then the structure should be independently grounded. If the structure is right up against or very close to the fence, conduct a specific grounding analysis. For grounding structures inside a substation fence, refer to Document 067910.

Overhead Ground Wire

Ground wires are installed on transmission lines to provide a path to ground for lightning strikes. This reduces the occurrence of lightning-related outages. Without overhead ground wires, a typical double-circuit, 230 kV tower line or single-circuit, 500 kV tower line will have approximately 5 outages/100 miles/year based on an isokeraunic level of 5 and a 25-ohm-footing resistance. This outage rate can be reduced to 1 outage/100 miles/year by the addition of two overhead ground wires.

In order to reduce power loss due to circulating induced current, the overhead ground wire on transmission lines greater than 2 miles in length should be insulated. When overhead ground wires are insulated, they are usually segmented into approximately 3-mile sections. Short lines, with a maximum length of 2 miles, shall be grounded.

Ground wire is normally required for:

- All high-capacity 230 kV lines.
- All 500 kV lines.
- In high isokeraunic level areas (5 strikes/year or greater).
- In close proximity to power plants (within 1 mile).
- In close proximity to 230 kV and 500 kV substations.

Short spans (less than 150 feet) into power plants and substations should not have a ground wire installed.

Fiberoptic Communication Cable (FOCC)

FOCC is optical ground wire (OPGW) or all dielectric self-supporting cable (ADSS). Minimum allowable electrical clearance requirements for FOCC are shown in Document 470591, Case 14.

When FOCC is in the overhead ground wire position, midspan separation between the FOCC and phase conductors is normally ensured by keeping the sag of the FOCC at 60°F, initial, 0# wind, sag to 80% of the phase conductor sag under the same conditions. Radial clearances should also be checked on steep incline spans and for differential ice loading conditions, when applicable.

On new structures, install OPGW to provide maximum 30° shielding angle to the phase conductor.

When ADSS fiberoptic cable is installed on transmission systems 115 kV and greater, the mounting location of the ADSS in relation to the phase conductors should be submitted to the cable manufacturer in order to perform an electric stress analysis. This is to determine if the electrical field strength exceeds the cable specifications and to evaluate if corona control is needed.

Table 16 Clearances for OPGW and ADSS in the Underbuild Position at 130°F, Final

Description	Rebuild	New Lines
FOCC Over Ground (urban areas)	18 ft.	20 ft.
FOCC Over Railway Track (not operated by overhead contact wires)	25 ft.	27 ft.
FOCC Over Railway Track (operated by overhead trolleys)	26 ft.	28 ft.
Distance of Conductor From Centerline of Pole (whether attached or unattached)	15 in.	15 in.
Distance of Conductor From the Surface of the Pole	3 in.	3 in.

OPGW fiberoptic cable on steel structures should be grounded at splice locations via a ground strap installed above the splice box. All conductive cable material (steel jacket and central core, if conductive) should be stripped beyond this point on the cable so that the remaining cable, when extended for splicing, is entirely non-conductive.

For fiberoptic cable installed at the distribution level, refer to Document 062719A for design and construction information.

Standard Material and Construction

All material and construction configurations shall meet PG&E standards as outlined in PG&E's Electric Overhead Construction Manual and the *Transmission Line Standards Manual*.

The standard type conductor used by PG&E is shown is Document 059626. The standard conductor purchase should specify specular conductor. Non-specular conductor should only be purchased if required for environmental mitigation. AAC type conductor is the preferred conductor for new construction. For bundled conductor construction, subconductor separation shall be 18 inches.

The aluminum strands in ACSS conductor are soft by design. As a result, in high wind areas, jumper loops and long vertical drops are subject to strand damage caused by low frequency oscillation. To minimize strand damage, install jumper strings to reduce the amplitude of conductor movement.

The preferred conductors for new construction are AAC and ACSR type conductors. The most economic conductor size shall be selected. AAC and ACSR conductors are expected to have a longer service life than ACSS type conductor. ACSS conductor is not approved for use on wood pole transmission lines or for use on new lines. ACSS is an acceptable conductor for use when reconductoring existing tower or tubular steel pole circuits.

Vibration dampers should be installed on all non-ACSS conductor as specified in Document 015073. Dampers are generally not installed on ACSS conductors. For spans 1,800 feet or longer, contact the manufacturer to determine if the specific conditions require pre-stressing the ACSS conductor during installation. The pre-stress condition shall be held for 10 minutes.

All new and rebuilt towers must be evaluated for climbing guards, marking, and stepping per UO Standard S1072. UO Standard S1072 will be used during the design process for new and reconstructed facilities (including reconductor projects) to determine if guarding is required.

Antennas may be installed on transmission structures. If possible, the antenna should not be located on the first structure outside the substation (the terminal dead-end structure).

The structure design criteria for 115 kV tubular steel poles is described in Document 051742.

Transmission Line Compliance Commitments and Design Requirements

The following is a list of compliance commitments for the design and construction of transmission lines.

CPUC Regulatory Requirements

- *G.O. 95* – "Rules for Overhead Electric Line Construction"
- *G.O. 128* – "Rules for Construction of Underground Electric Supply and Communication Systems"
- G.O. 26–D – "Regulations Governing Clearances on Railroads and Street Railroads with Reference to Side and Overhead Structures, Parallel Tracks, Crossings of Public Roads, Highways and Streets"
- G.O. 131D – "Rules Relating to the Planning and Construction of Electric Generation, Transmission/Power/Distribution Line Facilities"
- G.O. 52 – "Construction and Operation of Power and Communication Lines for the Prevention or Mitigation of Inductive Interference"

PG&E Design Requirements

- Document 470591 "Electrical Clearances for 60 kV, 70 kV, 115 kV, and 230 kV Overhead Transmission Lines"
- *Electric Overhead Construction Manual*
- *Transmission Line Standards Manuals* 1 and 2
- Transmission Line EMF Guidelines (PG&E)
- *Transmission Line Engineering Manual*
- *Transmission Line Design Manual*
- *Utility Operations Policies, Standards, and Guidelines*
- UO Guideline G11030 – "Overhead Transmission Line Naming and Line Numbering"
- UO Guideline G11073 – "Numbering Overhead Transmission Line Structures"
- UO Standard S1072 – "Requirements for Marking, Guarding, and Stepping of T&D Towers and Lattice Steel Poles"
- Civil Design Criteria Memorandum - DCM CST-04

Standard Material and Construction (continued)

Other Requirements

- Cal/OSHA Division of Occupational Safety and Health, Chapter 4, Subchapter 5, Group 2, Article 37– "Provisions for Preventing Accidents Due to Proximity to Overhead Lines"
- FAA Title 14, Code of Federal Regulations (14 CFR), Part 77– "Objects Affecting Navigable Airspace"
- FAA Order 8260 - "U.S. Standard for Terminal Instrument Procedures (TERPS)"
- FCC Title 47, Code of Federal Regulations (47 CFR), Telecommunication, Chapter I, Part 15 "Radio Frequency Devices"
- *Suggested Practices for Raptor Protection on Power Lines*: The State of the Art in 1996 (EEI)
- *Mitigating Bird Collisions With Power Lines*: The State of the Art in 1994 (EEI)

Other References

- National Electric Safety Code - 2002 (or most recent revision)
- CPUC *General Order (G.O.) 95* - 2007 (http://WWW.CPUC.CA.Gov/Published/Graphics/655.pdf)
- Cal/OSHA, Title 8, Chapter 4, Subchapter 5 (http://WWW.Dir.CA.Gov/Samples/Search/Query.htm)

Revision Notes

Revision 10 has the following changes:

1. Revised insulation criteria.
2. Revised Table 12 on Page 10.
3. Revised raptor safety requirements.

Contractor, by signature below, asserts and confirms receipt of all files including but not limited to those below as engineering content for Waves 14, 15, 16 and 20 NERC Mitigation engineering attached herein and incorporated by reference.

1. PLS-CADD files, assessment document and video files by circuit listed below:

Wave 14
Caribou-Table Mountain 230kV
Paradise-Table Mountain 115kV
Caribou-Palermo 115kV
Palermo-Wyandotte 115kV

Wave 15
El Dorado-Missouri #1 115kV
Rio Oso-Nicholas 115kV

Wave 16
Eagle Rock-Cortina 115kV
Eagle Rock-Redbud 115kV
Ignacio-Mare Island #1 115kV
Ignacio-Mare Island #2 115kV
Ignacio-San Rafael #1 115kV

Wave 20
Vaca-Vacaville-Cordelia 115kV
Vaca-Vacaville-Jameson-North Tower 115kV

CONTRACTOR: BURNS & McDONNELL ENGINEERING COMPANY, INC.	
Signature and Date	1-8-14
Name	JAMEY M BERTRAM

NERC Priority II Mitigation Waves 14-20 Bid Schedules (contingent on a contract execution date of 1/6/2014)

Circuit Name	Work Order	Design Start	Preliminary Scope Documents Issued	30% Design Issued	BMcD Submit to Civil/TLINE Review	Civil/TLINE Complete Results	BMcD Issue 60% Documents For Review	60% Review Comments	BMcD Issue 95% Dwg's For Review	95% Review Comments	Issue IFC pkg. PM/Construction
Group Wave 14 Projects											
Caribou-Table Mountain 230kV	30951931	02/03/14	02/28/14	04/18/14	05/16/14	06/06/14	07/03/14	07/25/14	08/29/14	09/12/14	10/01/14
Paradise-Table Mountain 115kV	30970621	02/03/14	02/28/14	04/18/14	05/16/14	06/06/14	07/03/14	07/25/14	08/29/14	09/12/14	10/01/14
Caribou-Palermo 115kV	30898366	02/03/14	02/28/14	04/18/14	05/16/14	06/06/14	07/03/14	07/25/14	08/29/14	09/12/14	10/01/14
Palermo-Wyandotte 115kV	30977360	02/03/14	02/14/14	03/14/14	03/21/14	04/04/14	04/11/14	04/25/14	05/02/14	05/16/14	05/30/14
Group Wave 15 Projects											
El Dorado-Missouri Flat #1 115kV	30940862	04/04/14	04/18/14	05/16/14	05/30/14	06/13/14	06/27/14	07/11/14	08/01/14	08/15/14	09/02/14
Rio Oso-Nicolaus 115kV	30932676	03/03/14	03/21/14	04/11/14	04/18/14	04/25/14	05/02/14	05/16/14	05/30/14	06/13/14	06/27/14
Group Wave 16 Projects											
Eagle Rock-Cortina 115kV	30932643	01/13/14	01/31/14	03/07/14	03/14/14	03/28/14	04/04/14	04/18/14	04/25/14	05/09/14	05/23/14
Eagle Rock-Redbud 115kV	30932644	01/13/14	01/31/14	03/07/14	03/14/14	03/28/14	04/04/14	04/18/14	04/25/14	05/09/14	05/23/14
Ignacio-Mare Island #1 115kV	30901383	01/13/14	01/31/14	03/07/14	03/21/14	04/04/14	04/25/14	05/09/14	05/30/14	06/13/14	07/01/14
Ignacio-Mare Island #2 115kV	30901383	01/13/14	01/31/14	03/07/14	03/21/14	04/04/14	04/25/14	05/09/14	05/30/14	06/13/14	07/01/14
Ignacio-San Rafael #1 115kV	30901384	01/13/14	01/31/14	03/07/14	03/14/14	03/28/14	04/04/14	04/18/14	04/25/14	05/09/14	05/23/14
Group Wave 17 Projects											
Mesa-Sisquoc 115kV	30945437	01/13/14	01/24/14	02/14/14	02/21/14	02/28/14	03/07/13	03/21/14	03/28/14	04/11/14	05/01/14
Moss Landing-Green Valley #1 & #2 115kV	30956768	01/13/14	01/31/14	03/07/14	03/14/14	03/28/14	04/11/14	04/25/14	05/02/14	05/16/14	05/30/14
Moss Landing-Salinas #1 & #2 115kV	30993367	01/13/14	01/31/14	03/07/14	03/14/14	03/28/14	04/11/14	04/25/14	05/02/14	05/16/14	05/30/14
Moss Landing-Salinas-Soledad #1 & #2 115kV	30932663	01/13/14	01/31/14	03/14/14	03/28/14	04/11/14	04/25/14	05/09/14	05/23/14	06/06/14	06/20/14
Group Wave 18 Projects											
Kings River-Sanger-Reedley 115kV	30932651	01/13/14	01/31/14	03/14/14	03/21/14	04/04/14	04/11/14	04/25/14	05/09/14	05/23/14	06/06/14
Oakhurst Tap 115kV	30932687	01/13/14	01/31/14	03/07/14	03/14/14	03/28/14	04/04/14	04/18/14	04/25/14	05/09/14	05/23/14
Group Wave 19 Projects											
Moraga-Lakewood 115kV	30950803	01/13/14	01/31/14	03/07/14	03/21/14	04/04/14	04/25/14	05/09/14	05/30/14	06/13/14	07/01/14
Moraga-Oakland "J" 115kV	30932659	01/13/14	02/14/14	03/21/14	04/04/14	04/18/14	05/09/14	05/23/14	06/13/14	06/27/14	07/18/14
Moraga-San Leandro #1 115kV	30932660	01/13/14	02/14/14	03/21/14	04/04/14	04/18/14	05/09/14	05/23/14	06/13/14	06/27/14	07/18/14
Moraga-San Leandro #2 115kV	30932680	01/13/14	02/14/14	03/21/14	04/04/14	04/18/14	05/09/14	05/23/14	06/13/14	06/27/14	07/18/14
Moraga-San Leandro #3 115kV	30932681	01/13/14	02/14/14	03/21/14	04/04/14	04/18/14	05/09/14	05/23/14	06/13/14	06/27/14	07/18/14
Group Wave 20 Projects											
Vaca-Vacaville-Cordelia 115kV	30932709	01/27/14	03/14/14	04/25/14	05/16/14	05/30/14	06/20/14	07/09/14	08/01/14	08/15/14	09/01/14
Vaca-Vacaville-Jameson-North Tower 115kV	30932710	01/27/14	03/14/14	04/25/14	05/16/14	05/30/14	06/20/14	07/09/14	08/01/14	08/15/14	09/01/14

ARTICLE VI: PRICING SPREADSHEET

BURNS & MCDONNELL ENGINEERING COMPANY

LUMP SUM PRICING BREAKDOWN

[redacted]

BURNS & MCDONNELL ENGINEERING COMPANY

LUMP SUM PRICING BREAKDOWN

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BURNS & MCDONNELL ENGINEERING COMPANY

LUMP SUM PRICING BREAKDOWN

WAVE 15

[redacted]

BURNS & MCDONNELL ENGINEERING COMPANY

LUMP SUM PRICING BREAKDOWN

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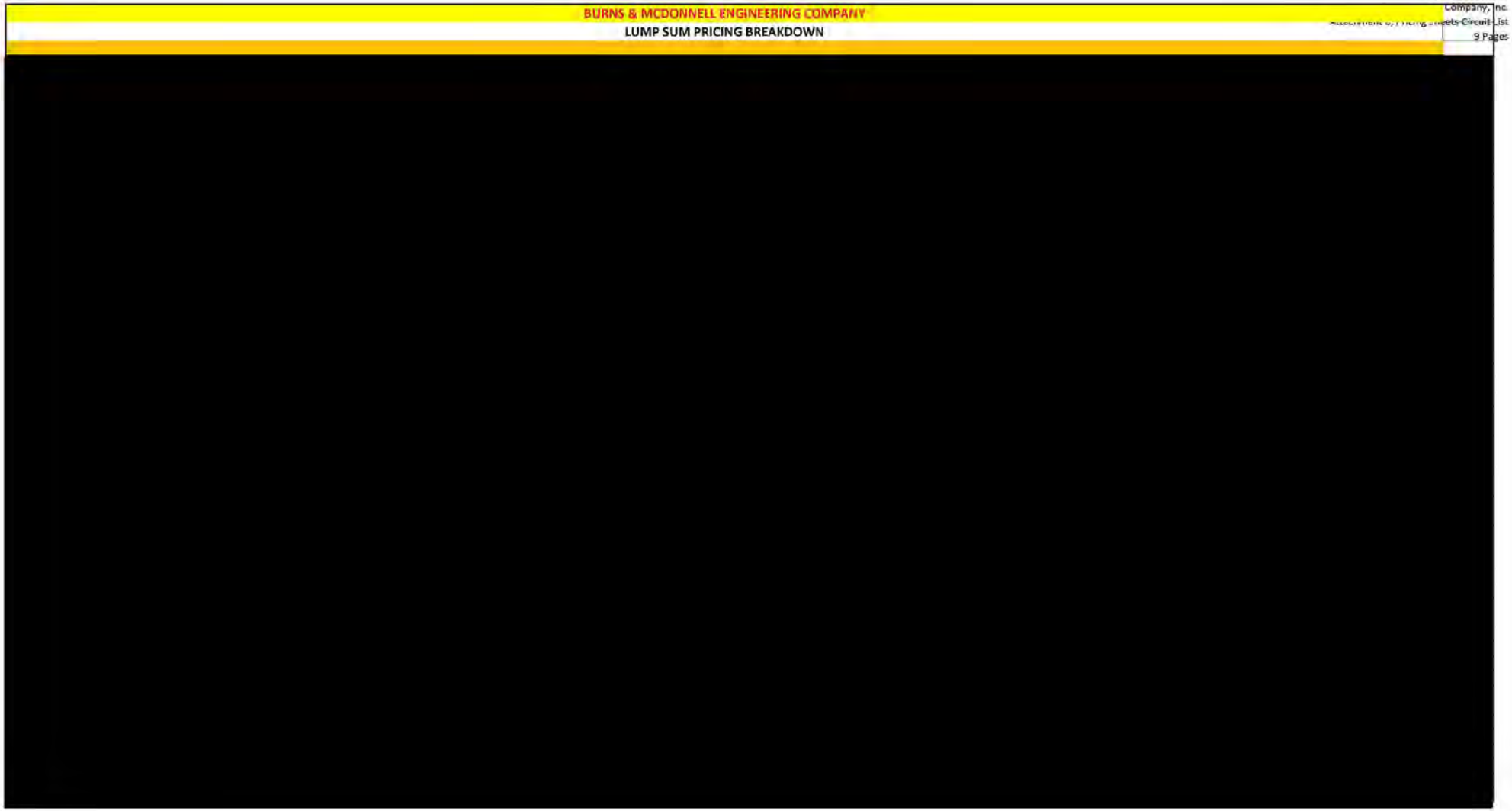
BURNS & MCDONNELL ENGINEERING COMPANY

LUMP SUM PRICING BREAKDOWN



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LUMP SUM PRICING BREAKDOWN

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Company, Inc.
9 Pages

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LUMP SUM PRICING BREAKDOWN

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Priority 2 Engineering Packages **Updated 11-1-2013**

	Discrepancies	Steel Locations	PM Order	Critical 60%	Issue for Construction	Construction Complete	Contract Completion Date (As Builts Due)
Wave 14							
Caribou-Table Mountain 230kV	27	14	30951931	7/1/14	10/1/14	4/19/16	8/19/16
Paradise-Table Mountain 115kV	45	36	30970621	6/1/14	10/1/14	2/1/16	6/1/16
Caribou-Palermo 115kV	116	55	30898386	6/1/14	10/1/14	4/19/16	8/19/16
Palermo-Wyandotte 115kV	3	3	30977380	4/1/14	6/1/14	10/22/14	2/22/15
Wave 15							
El Dorado-Missouri #1 115kV	7	4	30940862	7/5/14	9/2/14	12/19/14	4/19/15
Rio Oso-Nicholas 115kV	22	13	30932676	5/1/14	6/28/14	11/30/14	3/30/15
Wave 16							
Eagle Rock-Cortina 115kV	23	13	30932643	4/15/14	6/1/14	11/21/14	3/21/15
Eagle Rock-Redbud 115kV	9	2	30932644	4/15/14	6/1/14	11/21/14	3/21/15
Ignacio-Mare Island #1 115kV	34	19	30901383	5/1/14	7/1/14	5/1/15	9/1/15
Ignacio-Mare Island #2 115kV	55	20	30901383	5/1/14	7/1/14	12/2/15	4/2/16
Ignacio-San Rafael #1 115kV	2	1	30901384	5/1/14	6/1/14	10/3/14	2/3/15
Wave 20							
Vaca-Vacaville-Cordelia 115kV	34	20	30932709	6/1/14	9/1/14	5/1/15	9/1/15
Vaca-Vacaville-Jameson-North Tower 115kV	68	43	30932710	6/1/14	9/1/14	6/29/15	10/29/15